THE HELP SYSTEM FOR MEDICAL DECISION MAKING

**Frank G. Yanowitz, M.D.; T. Alan Pryor, Ph.D.;
John D. Morgan, Ph.D.; Homer R. Warner, M.D., Ph.D.***

INTRODUCTION

The continuing proliferation of new medical knowledge has placed the physician who must use this knowledge for patient care in a most difficult predicament. The practice of modern medicine is becoming increasingly complex and sophisticated. Patients are now living to an age where multiple coexisting medical problems must be dealt with before a successful outcome can be anticipated. Clearly some means must be found for assisting the physician in his primary decision making role in managing the complex medical data needed for patient care. The purpose of this paper is to describe a computer-based medical information system designed to improve health care delivery in a variety of clinical settings.

The HELP System (Health Evaluation through Logical Processing) was developed to provide standardized sets of rules or criteria for operating on a patient's data base in order to yield meaningful diagnostic and management decisions revelant to the care of that particular patient. The following discussion will consider each of four basic elements making up the HELP System currently in operation at the LDS Hospital in Salt Lake City. The *first* is a series of programs for gathering patient data using a variety of data input mechanisms. The *second* is the file structure of the patient's medical record. The *third* element is a file containing the logic by which various rules and criteria can be applied to the patient's data base for medical decision making. The *fourth* is a set of file management programs which control the interaction among the first three components.

DATA ENTRY SYSTEMS

A variety of mechanisms are now available for processing the primary or "raw" data obtained from patients during the course of their medical evaluations. Clinical data from the patients' medical history and physical examination as well as data from the various laboratories in the hospital may be entered via computer terminals either through structured or unstructured formats. The structured format is best exemplified by the self-administered automated patient history whereby the patient directly enters symptom information by responding to a series of multiple choice questions displayed on the terminal's CRT. The physician may also use a structured data entry format when entering initial physical examination data obtained on a new patient.

Isolated data items may also be entered into the patient's computer record using an unstructured data entry program called *ENTR*. When this program is called by a physician or paramedical person at a terminal several different types of clinical data may be entered just by typing in the first few letters of the data item. For example, a physician may want to enter a new heart murmur which has developed in his patient since admission to the coronary care unit. Rather than go through the complete structured physical examination program, he could call ENTR and type in "murm". The program responds by displaying all the heart murmurs and relevant descriptors on the CRT. The physician then chooses the particular data items causing them to be in the patient's file. Another example of unstructured data

*LDS Hospital, Salt Lake City, Utah.

entry is the entry of drug information from the hospital pharmacy.

In addition to the various clinical data programs described above, a number of physiological signals are directly processed from the patient in several clinical settings. In the intensive care units, for example, on-line monitoring of ECG rhythm information as well as arterial and venous pressure signals provide a nearly continuous source of information for subsequent decision making and patient management. More detailed computer ECG processing is also available for routine ECG analysis as well as during exercise stress testing. Physiological signals from the cardiac catheterization and pulmonary function laboratories including 2-dimensional video and radiographic images are also entered and processed directly by the computer.

THE PATIENT FILE

The second basic element of the HELP System is the patient data file. This file includes a set of patient identification records, one for each patient in the system, and a collection of data "pages" where time-oriented information is stored. Each patient is assigned a unique hospital number by which he is identified in the patient directory. This directory also locates the identification (ID) record for each patient. Data found in the ID record consist of demographic information as well as pointers to the various data pages obtained via the many data entry formats described above. The data pages are arranged according to the type of data that is stored in the patient record and defined by a particular *data class* and *field code*. The physical examination data, for example, are located in data class 7. Within that data class the cardiac exam is field code 12.

A particular set of findings in the cardiac exam are coded as "nouns", "adjectives", and "adverbs". As an illustration, consider entering the findings of a grade 2/6 systolic ejection murmur heard at the apex using either a structured or unstructured format. The codes for these findings might be stored in the patient's file as follows:

noun 3 = murmur; adjective 7 = systolic ejection; adverb 1 = apex; and adverb 5 = grade 2/6. These codes would be located in pages assigned to data class 7, filed code 12 according to the data and time when they were entered by the pysician. This type of data is an example of processing a variable length string of information. The entries in a patient's file are tightly coded, but each code can be interpreted by the system dictionary as English language text thereby allowing the user to enter and retrieve all information in natural language.

A different type of data format is used for storing fixed length information such as might be obtained from ECG or spirometry signal processing. In this format the position of the item (word character or bit) in the data field define the item. For instance, in the case of spirometry measurements, the second word in the field is always the forced vital capacity (F.V.C.) expressed as percent of predicted F.V.C.

Another file in the patient's computer record contains information regarding decisions made from other data already processed. This is the patient's *problem list.* The decisions represent conclusions made after analysis of the patient's data base and any previously defined problems. The mechanism for arriving at these conclusions will be discussed in the following section.

THE LOGIC FILE

Probably the most unique feature of the HELP System for medical data management is the "HELP sector" concept. It is through this mechanism that the medical expert can construct a system of rules and criteria for a particular class of medical decisions which can then be applied to all the patients having data relevant to those decisions. In order to understand how this particular element of the HELP System might be used in the day-to-day management of patients, a consideration of the types of decisions needed for patient care is first necessary. Essentially these decisions can be subgrouped as follows: 1) data interpretation and diagnoses; 2) classification of clinical status; and 3) patient management.

DATA INTERPRETATION AND DIAGNOSIS

Following the entry of primary data into the patient record the first level of decision making is concerned with interpreting various items of information and making diagnoses whenever possible. As an example, consider the interpretation of parameters derived from the patient's ECG which has been processed by the computer. Criteria provided by an expert in the field of electrocardiography are stored in the form of HELP sectors within the computer. If the patient's ECG data satisfy the criteria for "myocardial ischemia" this interpretation is added to the patient's problem list as a part of the patient file. If, in addition, clinical data are present in the data file describing a history of chest pain, and if a laboratory finding of elevated creatine phosphokinase has been processed, an additional diagnosis of "acute myocardial infarction" would be established.

From this example of medical decision making the various components of a HELP sector can be identified. The *message* of the sector (eg. "acute myocardial infarction") is applied to a particular patient if his data satis-

fy the logic represented by the sector. This message may be added to the patient's problem list, printed out as part of a report, or displayed on a CRT terminal. The message may also generate an alarm in an intensive care unit (eg. "ventricular tachycardia").

The second component of a HELP sector is a list of *items*. Each item describes a search to be made (eg. elevated CPK enzyme over the past 24 hours), as well as the maximal, minimal, or mean values of that particular items. The last component of the sector consists of one or more *statements* relating the various items on the item list. These statements may be Boolean (true or false), arithmetic, probabalistic, or a combination of these. A special statement called the *final evaluation statement* will result in either a numeric value being generated for the sector or a true-false value depending on the nature of this statement. It is the result of this final statement which corresponds to the decision of the sector.

PATIENT MANAGEMENT

An example of how a HELP sector might be constructed to be used in patient management decisions is illustrated below. The HELP sector is written to define the criteria for inserting a temporary transvenous pacemaker in a patient with an acute myocardial infarction. The sector suggests inserting such a pacemaker when the following requirements are met:

A. The patient must have an acute infarction as defined by previous HELP sectors, and
B. The patient must have at least one of the following indications:
   1. Any bradycardia with a heart rate of less than 45 per minute and refractory to atropine therapy.
   2. Mobitz I AV block with a heart rate of less than 50 per minute and refractory to atropine therapy.
   3. Mobitz II AV block.
   4. Acute left bundle branch block
   5. Acute bifascicular block.
   6. Complete AV block.

The HELP sector would be constructed as follows:

MESSAGE: "Suggest temporary transvenous pacemaker"

STATEMENT: A AND (D OR F OR G OR H OR I OR J)

ITEM	DESCRIPTION
A	Acute myocardial infarction
B	Atropine, 1 hour ago to now
C	Heart rate, last since B
D	C less than 45
E	Mobitz I AV Block
F	E and (C LT 50)
G	Mobitz II AV block
H	Acute left bundle branch block
I	Acute bifascicular block
J	Complete heart block

All the items in the item list are searched for in the patient's data file and if the final evaluation statement is true the message will appear as either a printed report or displayed on the CRT terminal in the coronary care unit.

FILE MANAGEMENT PROGRAMS

The fourth basic element of the HELP System is a series of programs which tie the first three elements together. Programs are now available which take data in through the various mechanisms already described, store the data in the appropriate locations within the patient's file, and call all the relevant HELP sectors to that class of data. As a result of this interaction decisions needed for patient care are automatically generated; interpretations of the data are made and presented to the medical staff in a variety of ways; diagnoses are made and added to the data base; and management decisions regarding further tests and therapies are suggested.

The HELP System that is currently being used at the LDS Hospital includes the following modes of operation:
1) interpretation of a variety of laboratory data including the heart catheterization lab, the exercise ECG lab, the pulmonary function lab and many other testing environments; 2) clinical diagnostic suggestions based upon a sequential Bayesean analysis of patient-entered historical data; 3) generation of alarms in the intensive care units based upon analysis of physiological signals; and 4) the prediction of untoward drug reactions as prescriptions are processed in the pharmacy.

CONCLUSIONS

Adequate characterization of the patient's clinical status depends upon more information than just knowing the anatomical and etiological diagnoses. The optimal management of patients with acute and chronic diseases requires knowledge of how "similar" patients have responded to various treatment modalities in the past. This implies that subgroups of patients having a particular disease or combination of diseases can be identified through various clinical and laboratory descriptors and that these subgroups have well-defined prognostic and therapeutic implications. The physician, faced with a difficult management decision for a particular patient will certainly benefit from knowing the

prognosis and therapeutic outcomes of similar patients managed in the past and, therefore, will choose a more optimal therapy for his patients based on these experiences.

The HELP System described in this paper represents only a beginning of a program designed to upgrade the delivery of health care in our medical facilities. As such, the challenge is really on those of us in the medical profession who are in a position to set standards of diagnoses and treatments based upon the most expert opinions in the field. The rules and criteria for medical decision making defined explicitly in the HELP sectors should be transferrable to other computer systems. The computer science aspect of such a system are trivial compared to the overwhelming task of construction of the appropriate medical criteria for the many difficult management decisions frequently seen in the everyday practice of medicine. We must all begin to collect standardized sets of data on patients seen with chronic diseases; to classify patients into clinical subsets that have important prognostic and therapeutic implications; to set up measurable targets of treatment; and to collect appropriate followup data to enable accurate analyses of the various outcomes. It is only in this way that so many of the current dilemmas in medical management can be resolved.